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14. ABSTRACT

The Combined Joint Force Combatant Commander (CJFCC) relies on the ability to maintain information superiority across the spectrum of military operations. The availability of accurate and timely information, as well as the ability to rapidly exchange this information, represent key components enabling effective command and control of the battlespace. Since *Operation DESERT STORM*, the U.S. has relied on space-based systems to achieve information superiority and enhanced combat effectiveness. In order to meet demands for critical information flow during recent military operations (to include *ALLIED FORCE*, *ENDURING FREEDOM* and *IRAQI FREEDOM*), the U.S. has needed to extend beyond the capabilities of dedicated DoD and national space assets, relying on the commercial space sector to provide critical force enhancement functions. Underlying this reliance are three primary premises: first, the U.S. military force cannot meet all mission requirements without tapping into the additional resources provided by commercial space; second, commercial space will continue to provide force enhancement capabilities beyond those derived from dedicated DoD systems; and thirdly, the use of commercial space products and services often facilitates improved information sharing with coalition partners. In effect, commercial space assets fill a niche as an operational "force enabler."

For the combatant commander to fully leverage commercial space capabilities, the role of commercial space must continue to be defined. This will be achieved by combining U.S. national and DoD policy with Joint service doctrine, while continually applying operational lessons learned concerning the best uses of commercial space in support of the warfighter.

This paper reviews the combatant commander's use of commercial space by analyzing a number of critical "utility factors" that must be considered when integrating commercial space into the operational battlespace. Additional mission areas are presented that possess potential for the combatant commander to further leverage commercial space capabilities.

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Defining Commercial Space's Place in the Battlespace

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A paper submitted to the faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations.

The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Department of the Navy.

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Abstract

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Introduction

Commercial space systems - more specifically the products, services and information they provide, are increasingly applied as "force enablers" to the U.S. military in the conduct of joint and coalition operations across the spectrum of conflict. During *Operations DESERT SHIELD* and *DESERT STORM*, the U.S. military relied on commercial space assets, to include leased satellite communications (SATCOM) which augmented dedicated, but limited, theater U.S. Military Satellite Communications (MILSATCOM) resources. In this case, the Navy and Army were able to leverage a leased service contract with the International Maritime Satellite Organization[i]. Since *DESERT STORM*, the U.S. military has increasingly leveraged commercial satellite services whenever these capabilities were determined to either augment dedicated U.S. national and military capabilities, or were deemed valuable in "filling a gap" to meet mission requirements.

The Department of Defense's (DoD) use of commercial satellite services depends on several factors, many determined by the particular function performed. For example, a factor common to all decisions to utilize commercial satellite services is that of availability (i.e., of commercial satellite communications channels/transponders, or of imagery of certain areas of interest). Availability represents just one factor that must be evaluated in determining the utility of commercial space applications to the combatant commander. Additional utility factors to include flexibility, timeliness, access and control, and commercial space's role as a "gap-filler" will be evaluated within the scope of this study.[ii]

The remainder of this paper will analyze the use of commercial space within two selected "space force enhancement" function areas; present U.S. national and DoD space policy applicable to the military's use of commercial space; evaluate key factors that must be

considered in determining the utility of commercial space to the operational commander; and finally, propose additional mission areas in which the combatant commander may further leverage commercial space capabilities.

Space Force Enhancement

This section reviews the primary mission areas of space operations, focusing on the key mission support functions in which commercial space systems have proven to enhance U.S. military mission accomplishment during recent joint and multi-national operations.

U.S. joint space doctrine identifies four primary mission areas: *space control*, *space force enhancement*, *space support*, and *space force application*.[iii] Of these four mission areas, it is within *space force enhancement* operations that the joint force commander has most effectively leveraged commercial space capabilities. Space force enhancement operations multiply joint force effectiveness by enhancing battlespace awareness and providing needed warfighter support. Space force enhancement is further broken down into five force enhancement functions: *intelligence, surveillance, and reconnaissance (ISR)*; *integrated tactical warning and attack assessment*; *environmental monitoring*; *communications*; *and position, velocity, time, and navigation*.[iv] Space force enhancement functions are provided by many sources to include military commands and organizations, government agencies such as the National Reconnaissance Office (NRO), National Security Agency (NSA), the National Geospatial-Intelligence Agency (NGA), the National Aeronautics and Space Administration (NASA), the National Oceanographic and Atmospheric Administration (NOAA), as well as commercial organizations, international consortia, and allied nation capabilities. With the possible exception of *integrated tactical warning and attack assessment*, each of the force enhancement functions has leveraged

commercial space to enhance battlespace situational awareness and operational effectiveness. In particular, commercial space assets have established their most prominent military support role in the areas of *geospatial information and data services (GI&DS)*[v] (as a subset of *ISR*), and *satellite communications* (SATCOM). It is across these two functional areas that the following sections will focus, exploring how commercial space capabilities have been leveraged and considering the factors that determine their operational utility.

Commercial Geospatial Information and Data Services (GI&DS)

A term commonly referred to in relationship to GI&DS support to military operations is *Geospatial Intelligence (GI)*.[vi] Recent examples of the U.S. military leveraging the commercial space market to secure GI&DS capabilities include the DoD's purchase, for the cost of almost 2 million dollars per month during November and December 2001, of the rights to all images of the *Operation ENDURING FREEDOM (OEF)* area of Afghanistan collected by the *Ikonos* commercial satellite operated by Denver-based *Space Imaging*.[vii] This purchase effectively gave the U.S. "shutter control" of the electro-optical 1-meter-resolution spacecraft. This deal proved useful for several reasons, to include providing U.S. military with current images of the Afghanistan Joint Operations Area (JOA), while also keeping these images out of adversary hands. Also, these images proved greatly beneficial because they could be shared with U.S. allies more easily than those taken by highly classified reconnaissance satellites.

Although commercial space imaging has been available to the military for decades, recent operations (to include *Operation IRAQI FREEDOM (OIF)* and *Operation ENDURING FREEDOM*) have highlighted the availability, quantity, quality, and timeliness of commercial products in support of the warfighter. Commercial space-derived GI&DS

products included: multi-spectral detection of military equipment in multiple environments (urban, rural, desert, vegetative, etc.); terrestrial surveys to include – beach landing, border access, river crossing, drop and landing zone suitability, vegetation and reservoir level analyses; force protection image maps for airfields and urban areas; unclassified images of enemy military equipment at schools, hospitals, etc. as well as Baghdad oil fires.[viii] The synergy gained by combining intelligence from U.S. military, commercial space, and national means has provided the combatant commander with excellent "fused" information. Figure 1 lists potential uses for commercial imagery in support of military operations.

Potential Uses for Commercial Imagery

Supplement to National Imagery	Unclassified Support and Products	Spectral Analysis
· Coverage in high-competition areas · Coverage on different days /times of day · Large-area scenes · Special studies · Denial and deception studies · Cloud belt areas	· Mission planning · Support to military exercises and operations · Non-combatant evacuation operations · Scene visualization: motion videos,anaglyphs, perspective views, 3D · Topographic maps, harbor and approach charts, VMAP I&II and combat charts · Digital elevation models (DEMs) · CIB · Sharing with coalition partners · On-site inspection packets · United Nations operations · Treaty monitoring · Official press releases	· Change detection · Camouflage, concealment, deception · Counternarcotics support · Mission planning · Hydrography and bathymetry · Terrain categorization · Environmental monitoring · Economic assessment: agricultural & forestry · Nuclear proliferation monitoring · Biological Warfare/ Chemical Warfare monitoring · Border/boundary delineation · Selected disaster relief support

Figure 1. Uses for Commercial Imagery[ix]

Commercial Satellite Communications (SATCOM)

The National Military Strategy (NMS) identifies information superiority as one of the foundations of Joint Vision 2010,[x] with the transformation of the joint force dependent upon information superiority as a key enabler.[xi] As has been repeatedly demonstrated during U.S. and coalition military operations in Kosovo, Afghanistan and the Arabian Gulf, this level of

information sharing requires the ability to maintain continuous networked communications and information flow within a given theater of operations, as well as between the theater and home-based headquarters. To do so requires a robust, dynamic and secure communications architecture. Despite incremental expansions/improvements in the DoD's MILSATCOM architecture, the demand for bandwidth[xii] always exceeds supply. In *DESERT STORM*, the total data rate required was 100 Mbps while *ALLIED FORCE* (Kosovo), which deployed a force only 10% the size of that used in *DESERT STORM*, required 250 Mbps.[xiii] Due to these expanding requirements, the U.S. military has placed itself in a position of critical dependence on commercial SATCOM as an operational level enabler of the NMS.

More than any other service, the U.S. Navy has relied on leased commercial SATCOM services to meet everyday operational requirements. This has involved the establishment of two primary contract vehicles, one through Inmarsat and the other through a program called the Commercial Wideband Satellite Program, or CWSP. All Navy aircraft carriers and fleet command ships, as well as a number of "large deck" amphibious units are currently equipped with CWSP terminals, while almost all of the Navy's "small boy" fleet, consisting mostly of frigate class ships (FFGs), are reliant on dedicated or time-shared Inmarsat channel assignments for routine communications requirements to include voice and data exchange services at up to 64 Kbps.[xiv] During *OIF* and *OEF*, the Navy has leased 125 Inmarsat channels at rates between 16 and 64 Kbps (~ 4.3 Mbps total), of which all channels have been used.[xv] Under the CWSP, 18 ships, each equipped with commercial C-band SATCOM terminals, have been provided an aggregate bandwidth of 30.5 Mbps, with the maximum bandwidth available per ship 2.048 Mbps. Since the satellite transponders on which the Navy has leased Inmarsat and CWSP SATCOM services are not owned by DoD,

the Navy has available for its use only those transponders (and associated channels) assigned to it, with oftentimes additional transponders residing on the satellite but allocated for commercial use.

DoD projects routine, day-to-day demand for long-haul, wideband[xvi] military communications to grow from 1 gigabit per second (Gbps) in the year 2000 to roughly 9 Gbps in 2008. As an add-on requirement (beyond routine use), projected surge demand ranges from less than 1 Gbps (in 2000) to approximately 4 Gbps in 2008.[xvii] In contrast, current MILSATCOM wideband capacity is on the order of 1 Gbps. Supply of wideband communications capacity by DoD assets thus already falls short of military demand, with projections of that shortfall possibly growing to more than 8 Gbps by 2008.[xviii] A graphical display of this disparity is shown in Figure 2 below. Based on U.S. MILSATCOM system upgrade schedules out to 2010, the gap will continue to be significant, making it necessary to continue reliance on commercial SATCOM to meet operational command, control and communications (C3) requirements.

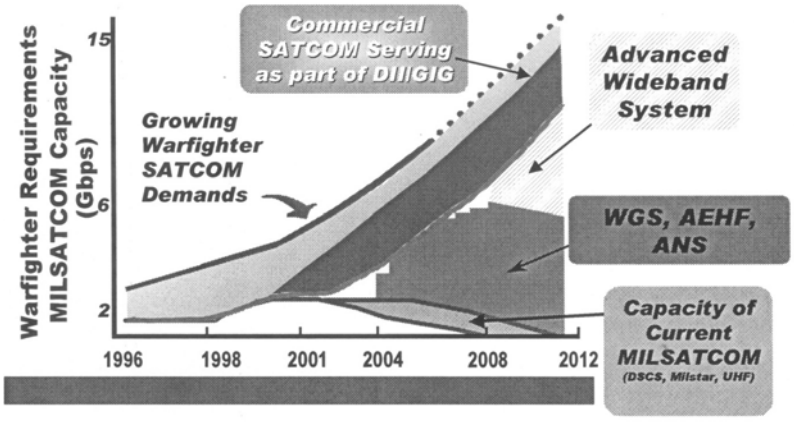

Figure 2. Commercial SATCOM Support to DoD

Applicable U.S./DoD Space Policy

Before the military services or warfighting commands can plan on using commercial space, to include the establishing doctrine or integrating concepts of operations and best practices, there must be rational policy in place that sets the "ground rules" for the use of space systems other than those owned and operated by the DoD.[xix]

Although not promulgated as official DoD policy, the Commercial Satellite Communications Initiative (CSCI) was a Congressionally-mandated, DoD-wide program initiated in 1995 designed to reduce the long-term cost of providing commercial satellite communications support to all DoD customers while also providing pre-arranged surge capability to support Joint Task Force (JTF) and related missions.[xx] The CSCI program was a strategy to use leased transponders, network management, and earth stations to satisfy non-mission-essential satellite communications at cost savings. The CSCI remains centrally managed by the Defense Information Systems Agency (DISA), which oversees the contracting of all leased communications and information transfer services by the DoD components.

In July 1999 the Secretary of Defense issued Department of Defense Directive (DODD) 3100.10, *DoD Space Policy*, a major revision, reflecting new priorities and the nation's evolving space policies and guidance since the Cold War. The scope of this directive is very broad, to include the policy, requirements generation, planning, acquisition, doctrine, exercise, operation, responsibilities, employment, and oversight of space and space-related activities within the DoD.[xxi]

In April 2003 President George W. Bush announced the most recent major policy statement affecting the commercial remote sensing and imagery industry. The *U.S. Remote*

Sensing Policy establishes guidance and implementation actions for commercial remote sensing space capabilities. Of note, although this policy supersedes PDD-23[xxii], the U.S. government still maintains significant control over U.S. commercial imagery companies.[xxiii] The Treasury Department keeps a list of "denied parties" – including Iraq – that cannot be sold "higher resolution" (less than 1-meter spatial resolution) imagery because of possible links to enemy states or foreign terrorist organizations (FTO). As per a law passed in 1998, it is also illegal to sell images of Israel at better than 2-meter spatial resolution.[xxiv]

Another significant policy direction requires the federal government to "rely, to the maximum practical extent, on U.S. commercial remote sensing space capabilities for filling imagery and geospatial needs for military, intelligence, foreign policy, homeland security, and civil users." Further, by implementing this policy, the U.S. government will refocus it's satellite imagery systems on meeting those federal needs "that cannot be effectively, affordably, and reliably satisfied by commercial providers, because of economic factors, civil mission needs, national security concerns, or foreign policy concerns."[xxv] In other words, for some needs commercial space is the "vendor of choice" for the government. The NGA will continue to have the lead role in collecting requirements and acquisition requests from civil and national security agencies, the military services, and combatant commands.

The most recent DoD policy affecting how the military services and DoD agencies will conduct space operations is DODD 5101.2, *Subject: DoD Executive Agent for Space,* which establishes revised policy and assigns responsibilities and authorities for the planning, programming, and acquisition of space systems within the DoD. DODD 5101.2 established the Secretary of the Air Force as the DoD Executive Agent for Space in addition to assigning specific responsibilities to DoD Service Component Secretaries.[xxvi] As DoD

Executive Agent for Space, the SecAF is to exercise DoD-wide responsibilities for the planning and programming of space systems and acquisition of DoD space Major Defense Acquisition Programs.

To summarize this section, national space policy directs the government and DoD to use commercial space capabilities whenever practical: to save money, to make up for national space capability shortfalls, and to provide a contractual means to deny adversaries access to U.S. commercial space capabilities when necessary. Although not explicitly stated, these policies also bolster the U.S. space industrial base and encourage advanced technology. The DoD, through agencies such as NGA and DISA, is required to closely coordinate with the Secretary of the Air Force on all space mission requirements.

Utility Factors

In order for a commercial space capability or service to provide operational utility to the combatant commander, it must pass certain tests that, based on the mission support function, make the commercial capability a "value added" to the fight. Several of these considerations will be analyzed in the following sections. Grouped together they will be referred to as "utility factors."

Commercial GI&DS Utility Factors

For commercial GI&DS, the three utility factors analyzed are:

- Availability
- Timeliness
- Use as a "Gap-Filler"

Availability of Commercial GI&DS – Commercial satellite imagery and remote sensing products are becoming increasingly available to the general public, private, and military communities. Commercial GI&DS availability is most often interpreted as the

volume, or number, of products made available to the combatant commander. However, the mechanism by which the combatant commander's staff is able to acquire commercial GI&DS is probably more important in evaluating availability. In a JTF organization, the J3 staff is augmented with a Space Liaison Officer (Space LNO) from U.S. Strategic Command's Space Operations Directorate, and beginning a couple of years ago, a Space Officer has also deployed as part of each Air Force Air and Space Expeditionary Task Force (AETF) and as a member of Army Space and Missile Defense Command's (SMDC) Army Space Support Teams (ARSSTs).[xxvii] These officers should be trained in and familiar with the process for procuring archived and special request commercial imagery products through the National Geospatial-Intelligence Agency (NGA). Deployed teams may also possess the capability to produce commercial imagery-based products utilizing deployable workstations.[xxviii]

With the increase in the number of commercial imagery providers and the further development of their respective systems, the DoD has already made moves to ensure they leverage the commercial market to meet availability requirements by establishing the *ClearView* acquisition initiative.[xxix] Figure 3 provides information on the lead U.S. companies in the commercial satellite Earth imaging market. [xxx]

Company Name	System Name	System Capabilities
DigitalGlobe Longmont, CO	QuickBird	carries one 61-cm panchromatic and one 2.4-m resolution multispectral land-imaging sensor.
Orbital Imaging Corp. (ORBIMAGE) Dulles, VA	OrbView-2 and 3	OrbView-2 carries 1.1-km ocean and land-imaging multispectral sensor. OrbView-3 carries 1.0-m panchromatic and 4.0-m multispectral land-imaging sensors.
Space Imaging Thornton, CO	Ikonos	Carries 1.0-m panchromatic and 4.0-m resolution multispectral land-imaging sensors.
SPOT Image Corp. Chantilly, VA	Spot 1, 2, 4 and 5	All Spot satellites carry 10-m resolution panchromatic and 20-m Resolution multispectral land-imaging sensors.

Figure 3. Lead U.S. Commercial Earth Imaging Companies and System Capabilities

Timeliness of Commercial GI&DS – Related to availability, timeliness refers to the time from request to delivery as well as the "revisit" period for collection of geospatial intelligence of a given area. Until recently (during *OEF* and *OIF*), timeliness has been the greatest limitation of commercial imagery systems, as commercial imagery timelines were inadequate to fulfill most theater collection requirements with revisit times ranging from 3 to 14 days. Added to this was the time it took to get commercial imagery delivered to theater, an additional time period usually measured in days. However, recently timelines have diminished through the implementation of improved processes and systems.[xxxi] Of special mention in the compilation of U.S. Joint Forces Command's lessons learned was that "for the first time there was access to commercial imagery that provided useful mission products inside operational timelines." Additionally, as stated in their report, "NIMA [now, NGA] was indispensable regarding the acquisition and transmission of commercial imagery by facilitating purchase and distribution in support of OIF."[xxxii] For some applications, the timeliness of commercial imagery products is not the determining utility factor. For example, commercial imagery can be used to confirm non-time-critical information such as the construction of facilities or bases.

Commercial GI&DS Role as a "Gap-Filler" – For purposes of this study, "gap-filler" refers to a system or capability that is able to meet operational requirements that cannot be wholly met by dedicated DoD/national assets. Traditionally, commercial imagery has not been relied upon to "fill gaps" existent in the DoD/national imaging architecture. However, in the upcoming years commercial imagery may be expected to fulfill such a gap-filler role, with the U.S. facing a potential gap in satellite imagery from national systems.[xxxiii] In a move made to increase the volume of higher resolution imagery available to government/DoD, and

largely spurred by the *2003 U.S. Commercial Remote Sensing Policy*, the NGA has implemented a new commercial imagery acquisition initiative called *Nextview*. The *Nextview* initiative is intended to drive commercial sector development of higher resolution imaging systems that can be expected to play an integral part in an overall future national imaging architecture.[xxxiv]

Commercial SATCOM Utility Factors

For commercial SATCOM, the three utility factors to be analyzed are:

- Flexibility
- Access and Control
- Use as a "Gap-Filler"

Flexibility of Commercial SATCOM – Flexibility refers to the ability to increase or decrease the level of use (measured in number of channels, transponders, or bandwidth) or to change the distribution (i.e., shift communications assets within or across geographic regions) of SATCOM resources. Flexibility provides the ability to support a range of military operations across various locations/environments. Some degree of flexibility is inherent in the use of dedicated DoD MILSATCOM assets, as channels can be apportioned between combatant commanders' geographic areas of responsibility (AOR) based on Chairman, Joint Chiefs of Staff (CJCS) priorities. Additionally, within a given AOR, MILSATCOM channels are always allocated and assigned to operational commands based on combatant commander priorities. Flexibility is limited by the quantity of resources used at any time and the geographic distribution of these resources. The quantity (i.e., number of channels and dedicated transponders) is effectively limited by the terms of the lease. An example of this arrangement was provided earlier, the Navy's use of CWSP during *OEF* and *OIF*. The distribution of commercial SATCOM assets is limited not only geographically (by

orbit track and transmitter "footprint") but also by the DoD's purchase and distribution of unique transmit and receive terminals required for use with the given commercial SATCOM system. For example, there is a limited degree of "surge capability" built into the Navy's CWSP agreement.[xxxv] This capability does not come from the ability to plus-up additional transponders, but rather, from the ability to back-haul (via terrestrial fiber optic cable) satellite-to-ground station links between adjacent geographic regions, thus increasing the number of ships that can operate in a given geographic area.[xxxvi]

Access and Control of Commercial SATCOM – DoD has defined assured access as "the certainty that the requisite amounts of SATCOM services are available and accessible when and where needed." Control "refers to the availability and mechanisms needed to effectively plan, monitor, operate, manage and manipulate the available SATCOM resources."[xxxvii] In order to have access and control of a communications satellite, one must either own the satellite or have dedicated control of a given satellite transponder. Citing the Navy's lease agreements under CWSP, the Navy does maintain unrestricted access rights to "their" leased transponders, maintaining the ability to plan and distribute CWSP communications resources. However, these commercial C-band satellites are remotely controlled and monitored by private entities (i.e., Intelsat, GE Americom, and PanAmSat). Moreover, the Navy is not responsible for commercial transponder health maintenance and upkeep (e.g., remotely switching back-up transponders through commercial satellite controllers). The five Navy CSWP Commercial Earth Stations (CESs) are responsible for maintaining strict control over earth station satellite terminal equipment (i.e., antennas, high-power and low-noise amplifiers, up and down-frequency converters, and satellite modems) but are not capable of steering commercial satellite transponders.[xxxviii] Steering a transponder

is a very important capability occasionally relied upon to provide service to specific units operating within a priority geographic region.

Another control limit inherent in the use of commercial communications satellites is that by not owning a satellite, the DoD cannot reposition the satellite in space in order to change its coverage area, or earth footprint.[xxxix] Since commercial communications satellites are built, launched and placed into orbit to provide commercial services, their orbital location is determined based on commercial or civilian, vice military, customer bases.

Commercial SATCOM's Role as a "Gap-Filler" – The DoD's leased commercial SATCOM program is meant to allow DoD to keep up with its ever-expanding communications and information sharing requirements (i.e., the demand for bandwidth) more so than to fill the (time) gap between fielding of successive U.S. MILSATCOM systems. Additionally, commercial SATCOM services have been acquired to support requirements during contingency operations, when demand surges beyond so-called day-to-day (routine) operations and operational support activities.[xl] See Figure 4 below.

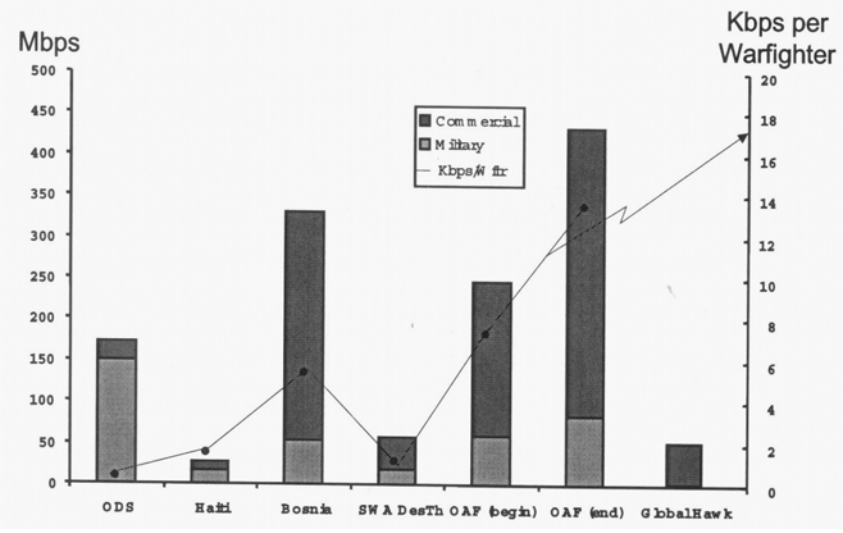

Figure 4. Commercial vs. MILSATCOM Use During Contingency Operations

The current U.S. MILSATCOM architecture consists of three primary systems providing global satellite communications across the military UHF, SHF, and EHF frequency spectrums.[xli] These systems are the UHF Follow-On (UFO) System operated by the Navy, the Defense Satellite Communications System (DSCS), and the Military Strategic and Tactical Relay (MILSTAR) System. System information is provided below in Figure 5.

System	Frequency Band	User
Ultra-High Frequency Follow-On (UFO)	UHF (243–318 MHz)	Narrowband communications for ships, aircraft, submarines, and ground forces
	SHF (8-GHz uplink only)	Uplink only for fleet broadcast systems
	EHF (44-GHz uplink/ 20-GHz downlink)	Some low-data-rate protected channels
		GBS package providing theater data broadcasts
Defense Satellite Communications System (DSCS)	SHF (8-GHz uplink/ 7-GHz downlink)	Fixed and deployed military users as well as government agencies
		Some protected wideband capacity available
Military, Strategic, and Tactical Relay Satellite (MILSTAR)	EHF (44-GHz uplink/ 20-GHz downlink)	Fixed and deployed military and government users needing the highest available levels of secure, survivable, and protected communications

Figure 5. Current U.S. MILSATCOM Systems

The Pentagon will upgrade each of these systems with new-generation systems this decade.[xlii] Of note, even with the upgrade of U.S. MILSATCOM systems providing increased bandwidth capacity, the demand for wideband (> 64 Kbps) satellite communications is projected to grow from 1 Gbps now to almost 13 Gbps in 2008 (sum of routine day-to-day plus contingency surge requirements), whereas the capacity of U.S. MILSATCOM capable of providing wideband communications is currently on the order of 1 Gbps. Although capacity will grow as the next-generation DoD satellite systems come into operation, it will remain substantially below the projected wideband demand.[xliii] Figure 6 graphically depicts projected DoD wideband requirements compared to U.S. MILSATCOM wideband capacity.

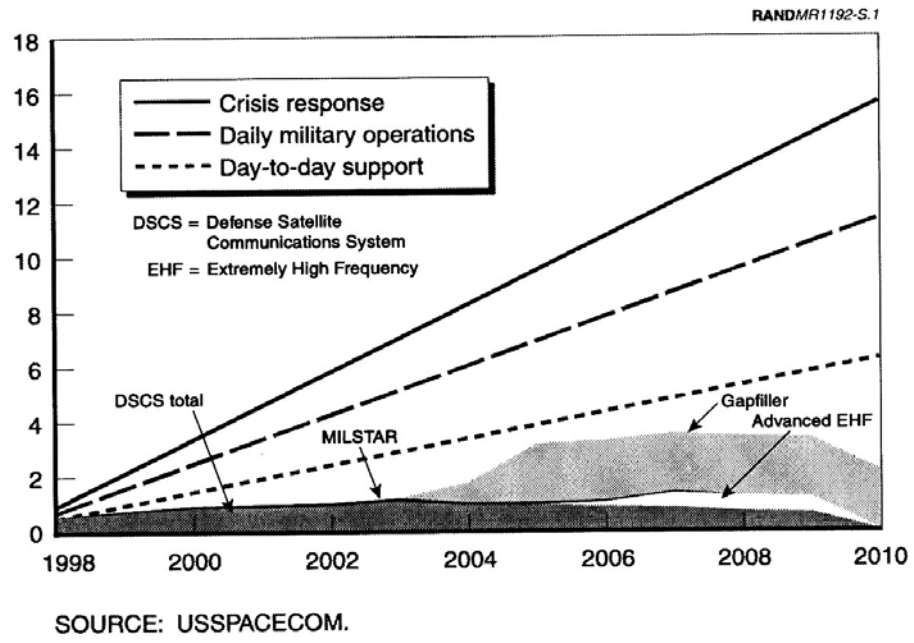

Figure 6. Wideband DoD MILSATCOM Capacity vs. Projected Demand

In summary, commercial SATCOM already meets a substantial part of the combatant commander's communications requirements. Leased commercial SATCOM systems, although filling a critical niche, are limited by the degree of flexibility and control available to the combatant commander. With a projected substantial bandwidth gap between dedicated MILSATCOM capacity and operational requirements, the DoD along with regional combatant commanders will need to determine commercial SATCOM's most efficient role in support of routine and contingency surge communications requirements.

Potential Commercial Space Mission Areas

Previous sections of this study have focused on the role of commercial space in support of recent operations, analyzing commercial space capabilities and applications within the realm of two of the five space force enhancement functions defined by joint doctrine.

Following are two proposed joint mission areas, beyond GI&DS and SATCOM, where the combatant commander, by advocating his requirements, has the potential to further leverage commercial space capabilities.

- *In-Transit Visibility/Total Asset Visibility (ITV/TAV)* – U.S. military services currently employ a number of systems which utilize Radio Frequency Identification (RFID) technology as a logistics management tool to provide automatic updates on the location and inventory of equipment moving to/from theater. Since RFID relies on the use of an RF interrogator at a specific location, it does not provide true In-Transit Visibility (ITV) but can only tell where cargo was last seen (where it was interrogated last), not where it is currently located. By incorporating a small Global Positioning System (GPS) transceiver within the RFID device, which would be capable of "reporting" to a constellation of commercial low-earth orbiting satellites, each item of cargo could be tracked in near real-time by use of an integrated joint service ITV system capable of providing Total Asset Visibility (TAV) to the J4. A system in place today that utilizes such a transponder-based satellite tracking system is the Movement Tracking System (MTS). MTS provides near real-time location data for vehicles, much as the Defense Transportation Reporting and Control System (DTRACS) did for U.S. Army Europe, Eighth U.S. Army, and the Coalition Forces Land Component Command in Iraq.[xliv]

- *Friendly Force Situational Awareness* - One of the more successful new communications devices used by joint U.S. forces in Afghanistan and Iraq was the Blue Force Tracker (BFT) system, a tracking and reporting device that uses satellite phone technology. A very useful function of BFT was to send instant messages between users of BFT display systems. The satellite-based communications utilized by BFT were much

preferred to Line-Of-Sight (LOS) radios because radios can experience problems with point-to-point terrain blockage or atmospheric interference. BFT enabled commanders to maintain a friendly force picture which was critical to avoiding friendly-fire situations when multiple units were operating in close proximity to each other and the enemy. BFT was first used in Afghanistan, allowing Special Operations Forces (SOF) headquarters in the U.S. and in the Persian Gulf to keep track Special Forces "A" Teams in country.[xlv] During OIF, BFT transmitters were distributed to infantry and tank companies, as well as some helicopters (like the leader of a group of gunships).

Based on its performance in Iraq, the Army intends to add blue-force tracking capabilities to a hand-held computer that is being developed for the *Land Warrior* program. This battle-management computer, called the Commander's Digital Assistant (CDA), is designed to help battalion and company commanders, as well as platoon leaders, maintain "situational awareness" of their troops as they move around the battlefield. The Army also intends to combine the CDA technology with the BFT device widely used in OIF – the Force XXI Battle Command Brigade and Below, or FBCB2. Another feature the Army wants in the CDA is L-band satellite connectivity, which is currently available in the FBCB2.[xlvi] Systems such as the BFT require communications architectures which provide secure data communications over the horizon with no single point in the system – be it an aircraft, UAV, or ground station – that can be the cause of network failure. Such architectures can be provided by a system of cross-linked, secure-capable, narrowband (< 64 Kbps) data transfer services such as those introduced by *Iridium* in June 2003.[xlvii]

The joint services will need to continue working together in determining requirements for a true common-operational-picture (COP) system that will provide friendly force

situational awareness and assist with fratricide prevention. Space-linked voice and data transfer services provided by low-earth orbiting commercial satellites should be considered in building an overall reporting and communications architecture.

Conclusion

As shown during recent military operations, the U.S. relies on the capabilities provided by the commercial space sector in order to achieve mission success. Based on rest-of-decade projections, the U.S. cannot meet SATCOM bandwidth requirements with solely DoD-owned and operated assets. Commercial SATCOM can be expected to meet U.S. military "gap-filler" requirements in terms of availability, but will be limited by flexibility, access and control factors. The combatant commander will need to determine the most efficient and effective employment of commercial SATCOM, whether it be for routine day-to-day communications or leveraged to meet contingency operations requirements.

U.S. National Space Policy coupled with recent DoD acquisition initiatives, *ClearView* and *NextView*, will facilitate further dependence on commercial GI&DS capabilities wherever practical in meeting military operational and national intelligence requirements. Commercial GI&DS has improved in terms of timeliness and availability, thus enhancing operational utility to the combatant commander. With an improved ability to deliver its products to the battlespace, commercial GI&DS can be expected to fill an even larger operational niche throughout the period when next-generation Earth imaging systems come on-line.

Space force enhancement will continue to benefit from the growing field of commercial space applications. As DoD Executive Agent for Space, it is paramount the Secretary of the Air Force lead U.S. joint service and DoD agency efforts to identify space

system requirements. In overseeing space systems acquisition and development programs, the Executive Agent for Space will be responsible for fostering the full integration of commercial space capabilities, which when combined with dedicated DoD and national systems, will provide the combatant commander a robust "operational toolbox" from which to maintain information superiority across the battlespace. As well, combatant commanders must identify their space force enhancement requirements now to ensure DoD accurately assesses its future need for commercial space capability.

End Notes

[i] Inmarsat, LLC was established in 1970 to provide worldwide mobile satellite communications to its customers, which initially consisted mostly of commercial merchant vessels. Now an 81 nation consortium, Inmarsat is headquartered in London and provides a broad range of satellite communications services to include voice, video teleconference (VTC) and data exchange services to commercial and government users worldwide.

[ii] Other factors that must be applied in determining the operational utility of commercial space system capabilities include quality of service, reliability, security, vulnerability, cost, and interoperability (between U.S. joint services and between U.S. and coalition partners). The US Air Force Scientific Advisory Board Report on "Availability and Survivability of Military Relevant Commercial Space Systems, and RAND's "Employing Commercial Satellite Communications: Wideband Investment Options for DoD" (2000) provide comprehensive analyses of respective title subjects.

[iii] Joint Chiefs of Staff, Joint Doctrine for Space Operations, Joint Pub 3-14 (Washington, DC: 9 Aug 1992), x.

[iv] Ibid.

[v] Dept of Defense Directive (DODD) 5030.59, Subject: National Imagery and Mapping Agency (NIMA) LIMITED DISTRIBUTION Imagery or Geospatial Information and Data (May 13, 2003) provides the following definition for Geospatial Information and Data: Information and data that presents or identifies the geographic location and characteristics of natural or constructed features and boundaries on the earth, including: statistical data: information derived from, among other things, remote sensing to include imaging, mapping, and surveying technologies; mapping, charting, and geodetic data. This information or data may be in several forms including hard copy maps, charts, or other products or materials, or in soft copy digital data on various media. The term includes information, data, and products previously identified as "mapping, charting, and geodesy" or "MC&G."

[vi] On Nov. 24, 2003 the President signed the 2004 Defense Authorization Bill, a provision of which authorized the National Imagery and Mapping Agency (NIMA) to change its name to the National Geospatial-Intelligence Agency (NGA).

[vii] Regalado, Antonio. "U.S. Allows Bird's-Eye View," Wall Street Journal, 21 March 2003, sec B., p.1, 3.

[viii] James R. Asker, "Shutter Control," Aviation Week and Space Technology, 17 (October 22, 2001): 25.

[ix] Presentation, "Commercial Imagery Program, Tom Henning" <http://ldcm.gsfc.nasa.gov/library/HSRCIW01/NIMA_Comm_Imagery_Program_Henning.pdf>, viewed 10 May 2004.

[x] Chairman, Joint Chiefs of Staff, National Military Strategy of the United States of America, (Washington, DC: 1997), 18.

[xi] Joint Chiefs of Staff, Joint Vision 2020, (Washington, DC: June 2000), 7.

[xii] Bandwidth is a measure of the throughput or data rate of a communications path. Bandwidth is measured in units of bits per second (bps), or most commonly kilobits (10^3 bits per second, Kbps), megabits (10^6 bits per second, Mbps), or gigabits (10^9 bits per second, Gbps).

[xiii] United States Air Force Scientific Advisory Board, Report on Availability and Survivability of Militarily Relevant Commercial Space Systems (March 2002), v.

[xiv] The author gained knowledge of the Navy's Inmarsat and CWSP commercial leased SATCOM programs through experience as Operations Officer/N3 at Naval Computer and Telecommunications Area Master Station, Pacific (NCTAMS PAC) during 2001-2004.

[xv] Trosien, Marc W. <marc.trosien@navy.mil> "RE: Commercial SATCOM Use and SATCOM Course CD." [E-mail to Bruce DeMello <bruce.demello@nwc.navy.mil>] 27 April 2004.

[xvi] Wideband refers to services having channels equal to or greater than 64 kilobits per second (Kbps). Narrowband channels typically provide voice services and specialized data services not needing high data transfer rates, whereas wideband services typically include video or imagery transfer, video-teleconference services, or the timely transfer of large data files.

[xvii] RAND, xvi.

[xviii] RAND, xvii. The fact that DoD-owned capacity falls short of current military demand is evidenced by the large amount of commercial capacity already leased by DoD. In the year 2000, at the time of the RAND report "Employing Commercial Satellite Communications: Wideband Investment Options for DoD," according to United States Space Command that amount was over 1 GHz of commercial bandwidth, which converted to data rate, was capable of carrying approximately 900 Mbps of digital traffic.

[xix] The overarching document which defines the United States' goals and provides guidance for the direction the nation will take in the pursuit of a national space program is the *U.S. National Space Policy*. The last National Space Policy was released in 1996. Per National Security Presidential Directive/NSPD – 15, the current administration's National Security Council (NSC), with the support of the Office of Science and Technology, is chairing a review of national space policies, using the Space Policy Coordinating Committee (PCC).

[xx] "Description: Commercial Satellite Communications Initiative (CSCI)." <http://www.fas.org/spp/military/program/nssrm/initiatives/csci.htm> [6 May 2004].

[xxi] Within DODD 3100.10, DOD Space Policy, Section 4.6. Planning, 4.6.1. Long-range planning objectives for space capabilities, subparagraph 4.6.1.3. states: Ensure civil and commercial capabilities are used to the maximum extent feasible and practical (including the use of allied and friendly capabilities, as appropriate), consistent with national security requirements. Under Section 4.10. Translating Operational Needs into Programs, 4.10.2. Acquisition, subparagraph 4..10.3. Preference for Commercial Acquisition, states: Acquisition of national security-unique systems shall not be authorized, in general, unless suitable and adaptable commercial alternatives are not available.

[xxii] Presidential Decision Directive (PDD) – 23, *Foreign Access to Remote Sensing Space Capabilities*, issued in 1994, was a landmark effort at crafting a regulatory framework and export regime for remote sensing satellites and their products. This policy directive issued by President Clinton cleared the way for the licensing of privately operated satellite imagery systems, aimed at boosting U.S. commercial initiatives. Additionally, PDD-23 included a provision that allows the U.S. government to require companies to turn off their cameras over "sensitive" areas in times of crisis. The provision was aimed at protecting U.S. troops in overseas operations such as the Arabian Gulf war. PDD-23 stated the government can require a commercial imagery system to limit data collection and/or distribution "during periods when national security or international obligations and/or foreign policies may be compromised."

[xxiii] Dept of Defense Directive (DODD) 5030.59, May 13, 2003, *Subject: National Imagery and Mapping Agency (NIMA) LIMITED DISTRIBUTION Imagery and Geospatial Information and Data* updates DoD policy and assigns responsibilities for the use, availability, and withholding of LIMITED DISTRIBUTION imagery or geospatial information and data distributed by, created by, or derived from NIMA information and data in the possession of, or under the control of, the Dept of Defense. Note this directive does not apply directly U.S. commercial imagery vendors, however, NIMA often will have purchased imagery or geospatial information products from U.S. companies.

[xxiv] Antonio Regaldo, "U.S. Allows Bird's Eye View," Wall Street Journal, 23 March 2003, Sec. B, p.1, 3.

[xxv] Frank Sietzen Jr., "Putting Bush space policy into commercial orbit," Geospatial Solutions, 7 (July 2003): 16.

[xxvi] Within DODD 5101.2, DoD Executive Agent for Space, under Section 6.3., Responsibilities of Heads of DoD Components, subparagraph 6.3.4. states: (DoD Components shall) develop DoD Component requirements and concepts for: space systems, space doctrine, education, and training requirements and standards; space research, development, testing, evaluation, and acquisition; related military construction; and space-related strategy and operations. In coordination with the appropriate DoD Components, provide such information to the DoD Executive Agent for Space. Where appropriate, use established DoD processes for the development of joint doctrine, training, and strategies.

[xxvii] US Army Space and Missile Defense Command (SMDC), Press Release, Space and Missile Defense Command Contributions and Lessons from Operation Iraqi Freedom, October 14, 2003.

[xxviii] The SMDC Spectral Operations Resource Center Forward (SORC Fwd) provided imagery support to Operation IRAQI FREEDOM, including the preparation of high-resolution images for Coalition Forces that permitted a better understanding of the terrain in specific areas of operation. Of particular importance, the SORC produced imagery-based spectral products for air-drop planning. These included two and three-dimensional perspectives of terrain and vegetation used to identify and eliminate sites that were unsuitable for airborne assault operations. Standard image maps were derived from high and medium resolution commercial imagery. The SORC mission during Operation IRAQI FREEDOM provides an excellent example of the variety and depth of products that can be produced using commercial/spectral imagery.

[xxix] In a move to ensure DoD availability high-resolution imagery from the next series of U.S. commercial imaging satellites, the National Geo-Intelligence Agency (NGA) recently awarded the ClearView contract to Orbital Imaging Corp. The ClearView contract provides ORBIMAGE with a guaranteed minimum value of $27.5 million over two years, of which approximately $10.5 million and $12 million represent minimum commitments to purchase imagery in year one and year two, respectively. ClearView represents a significant

improvement over previous purchase arrangements. Cumbersome multi-tier licensing structures have been replaced by a single license allowing NGA to share imagery with all potential partners (military, intelligence, diplomatic, allied nations and coalition partners, federal civil agencies, law enforcement and first-responders). ClearView also provides more favorable access and priority for the government.

[xxx] 2003 Aerospace SourceBook, Aviation Week and Space Technology, (January 19, 2004): 260-261.

[xxxi] A key element in establishing and maintaining information and decision superiority is timely access to theater imagery. Accurate and timely imagery is a cornerstone of successful operational planning and execution. Operation IRAQI FREEDOM confirmed the importance of having an in-theater commercial imagery direct downlink capability to move commercial imagery more effectively to meet operational timelines. The new *Eagle Vision* system, deployed to the United Arab Emirates, provided an in-theater direct downlink of commercial satellite imagery. Using *Eagle Vision* proved appreciably faster than getting imagery from commercial vendors through the NIMA Commercial Satellite Imagery Library (CSIL). The Spectral Exploitation Cell-Transportable Receiver (SPECTR) could receive imagery from *Eagle Vision* in about 12 hours on average, from the time the image was collected. In contrast, it required an average of 24 hours, from collection to receipt, for SPECTR to receive imagery from CSIL. (from "Space and Missile Defense Command contributions and lessons from Operation Iraqi Freedom," US Army Space and Missile Defense Command (SMDC) Press Release – 14 Oct 2003).

[xxxii] US Joint Forces Command, Joint Lessons Learned: OPERATION IRAQI FREEDOM Major Combat Operations, Coordinating Draft (Norfolk, VA: March 1, 2004), 67.

[xxxiii] Wall, Robert, and Asker, James R. "Unrolling the Welcome Mat The White House commits to using commercial space imagery and opens the door to exports of ready-to-operate systems." Aviation Week and Space Technology. 158 (May 19, 2003): 35.

[xxxiv] Ibid.

[xxxv] Under the Commercial Wideband Satellite Program (CWSP), the Navy currently leases transponders on six commercial satellites that are in geosynchronous orbit over five fleet operational areas: Pacific, Western CONUS, Eastern CONUS, Atlantic/Mediterranean, and Arabian Gulf/Indian Ocean. Total throughput varies depending upon the satellite and the number of transponders, but is as high as 9.0 Mbps supporting as many as six ships per area. Circuit-level signal patching within and between operational areas is performed by both the Navy's regional NCTAMS (three global, Atlantic, Pacific, and Central Europe) or Naval Computer and Telecommunications Stations (NCTSs) who maintain terrestrial links with the five global CWSP Commercial Earth Stations (CESs): Steele Valley, CA; Pearl City, HI; Holmdel, NJ; Martlesham, UK, and Madley, UK.

[xxxvi] To do this requires detailed coordination between the Navy commander's N6 staff and the servicing regional Naval Computer and Telecommunications Area Master Station (NCTAMS) to ensure proper channel assignments and end-to-end connectivity through terrestrial Commercial Earth Stations (CESs).

[xxxvii] RAND, 60.

[xxxviii] Powell, Ronald B. <Ronald.B.Powell@navy.mil> "RE: Request for Assistance – CWSP particulars." [E-mail to Bruce DeMello <bruce.demello@nwc.navy.mil> [10 May 2004].

[xxxix] This is only a consideration for satellites in geosynchronous earth orbit.

[xl] During the later stages of *Operation ALLIED FORCE* (Kosovo campaign), 60 percent of the satellite communications used were provided by commercial entities. This is a significant change from *DESERT STORM* where 85 percent of communications were provided by military satellites. (Space Operations, Air Force Doctrine Document 2-2, 27 Nov 2001, p. 37.)

[xli] The military Ultra-High Frequency (UHF) frequency band ranges from 225 MHz-400MHz. The Super-High Frequency (SHF) band ranges from 3 GHz-30 GHz. The Extremely-High Frequency (EHF) band ranges from 30 GHz-300 GHz.

[xlii] The U.S. Navy's Mobile Users Objective System (MUOS) is scheduled to enter service in 2009. The satellites will provide unprotected, narrowband (64 Kbps and below) UHF frequency communications capable of reaching hand-held devices under adverse signal and weather conditions. (Signal, Dec 2003, "Spacecraft, Ground Equipment Triad Ensures Combat Connectivity," 58. p. 35).

The Wide-band Gapfiller Satellite (WGS) system will consist of three commercial, but DoD-owned, high capacity, military frequency modified satellites. The WGS will provide a limited military SHF/commercial Ka band capability during the transition between the DSCS Service Life Extension Program (SLEP) and an objective wideband system. (Overview: Wideband Gapfiller, NSSRM website <http://www.fas.org/spp/military/program/nssrm/initiatives/gapfill.htm>, 6 May 2004).

The Advanced Extremely High Frequency (AEHF) satellite system is forecast to have 12 times the bandwidth of today's MILSTAR network. ("Space Pays Dividends – Milspace resources have become the backbone of combat operations, and warfighters are demanding even more," AW&ST, June 9, 2003, Issue 23, p. 52).

[xliii] RAND, xvi-xvii.

[xliv] Robert F. Carpenter, "Potential Uses for RFID Data," Army Logistician, 1 (Jan/Feb 2004): 20.

[xlv] "Iraq Lessons Learned – Combat Lessons Learned," <http://www.strategypage.com/iraqlessonslearned/iraqwarlessonslearned.asp>, StrategyPage April 22, 2004 [22 April 2004].

[xlvi] Sandra I. Erwin, "Army to Upgrade Land Warrior System With Blue-Force Tracker," National Defense Magazine, February 2004, <http:www.nationaldefensemagazine.org/article.dfm?Id=1339> [11 May 2004].

[xlvii] Iridium (LLC) launched new short burst data (SBD) and short message services in 2003. This capability allows applications for asset tracking that will enable military units to track key assets that "last mile" to the beach or to the objective. Coupled with the Global Positioning System (GPS), SBD can be used by units and platforms that have been shortchanged in tactical communications. For example, amphibious assault vehicles and remote sensor sites could have real-time reporting and location capabilities. (Rear Admiral Hugh D. Wisely, U.S. Navy (Retired), "Iridium Satellite Communications Are the Wave of the Future," Proceedings, February 2004: 77.

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